Appendix 9-E

EXAMPLE OF A METHOD TO ESTIMATE SEDIMENT ACCUMULATION

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9-E.1.0 METHODOLOGY

There is limited data available about the variations in sediment accumulation. Monitoring of new ponds and retrofit ponds (converted ponds in older established areas) indicates a significant difference in sediment buildup for different ponds at different time periods. While sediment accumulation is typically rapid during the construction period, once a catchment area is completely developed and stabilizing vegetation is established, sediment accumulation drops markedly.

A study was done in Ontario, Canada, wherein continuous simulations were performed for end-of-pipe stormwater management facilities to assess the rate of sediment accumulation (OME, 2003). The average annual TSS removal efficiencies with specific volumes of storage were determined using continuous simulations and a sedimentation model. The required maintenance frequency was then determined based on the annual sediment accumulation and resulting annual loss in the facility's storage capacity.

The continuous simulations indicated total suspended solid (TSS) removal efficiencies for different end-of-pipe SWM facilities with varying volumes of storage and different levels of imperviousness. The removal efficiencies were converted into volumes of sediment captured by each type of facility on an annual basis. A set of curves was developed which indicate sediment removal frequency for facility type, storage volume, and level of upstream imperviousness (**Figures 9-D.1 to 9-D.4**).

Sediment accumulation reduces the effective storage volume and the long-term BMP removal efficiency for suspended solids. The theoretical maintenance frequency for sediment removal can be calculated based on the rate of performance reduction with loss in storage volume. The theoretical performance-storage relationship does not account for conditions such as upstream development and inadequate sediment and erosion control. Therefore, predicted maintenance frequencies are only estimates which should be refined based on operational and maintenance experience in the field.

The performance-storage curve becomes asymptotic quickly (i.e., a large increase in storage is required for small improvements in the removal performance). This means that for typical BMP storage volumes there must be a considerable loss in storage to reduce the effectiveness of the facility. The study concluded that 5% was an acceptable reduction in TSS removal efficiency due to gradual sediment accumulation. The time frame to reduce the storage to the point that the annual removal efficiency was 5% less than the original efficiency indicates the maintenance frequency for that BMP with that particular storage volume.

If excess storage is provided to lengthen the intervals between required maintenance, the time frame to reduce the efficiency by 5% below the original efficiency should be calculated. For example, if 80% removal is required, but excess storage is provided resulting in an initial efficiency of 85%, then maintenance would be required when the performance efficiency was reduced by 10% (i.e., 5% below the original target efficiency).

As noted above, a set of curves was developed which indicates sediment removal frequency for facility type, storage volume, and level of upstream imperviousness, based on the continuous simulation results and the requirement for maintenance with a 5% loss in TSS removal performance (**Figures 9-D.1 to 9-D.4**). These curves are best-fit lines based on linear regression over a period of 50 years. They indicate that there is a linear relationship between maintenance frequency and BMP storage volume. These graphs can be used to determine the required sediment removal frequency given the BMP type, storage volume, and imperviousness level of catchment basin.

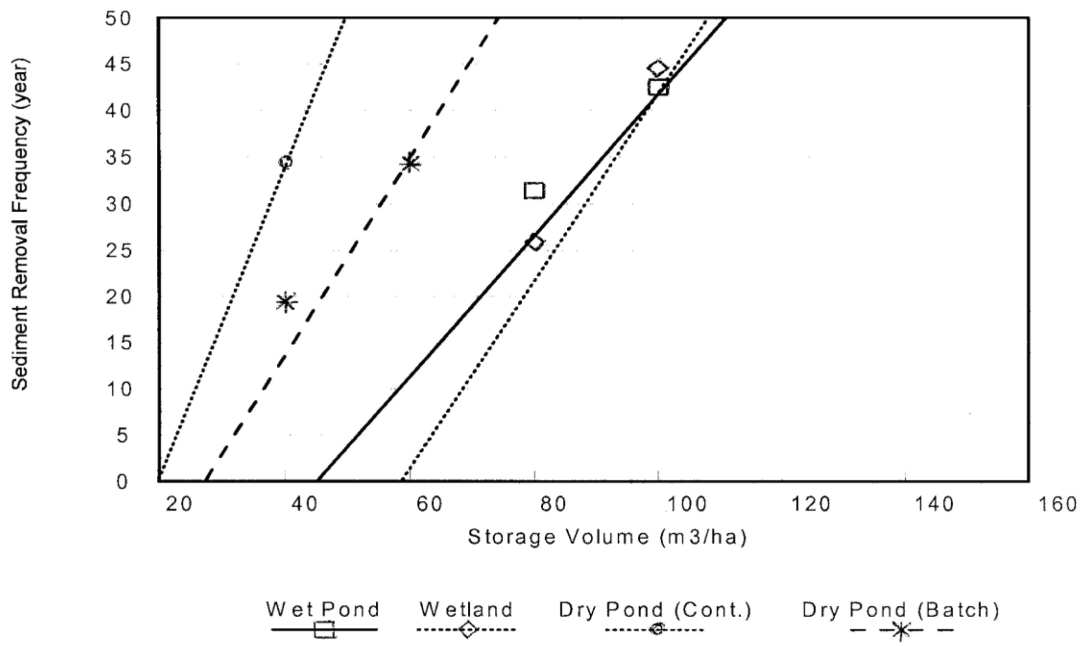

Figure 9-D.1. Storage Volume vs. Sediment Removal Frequency – for 35% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

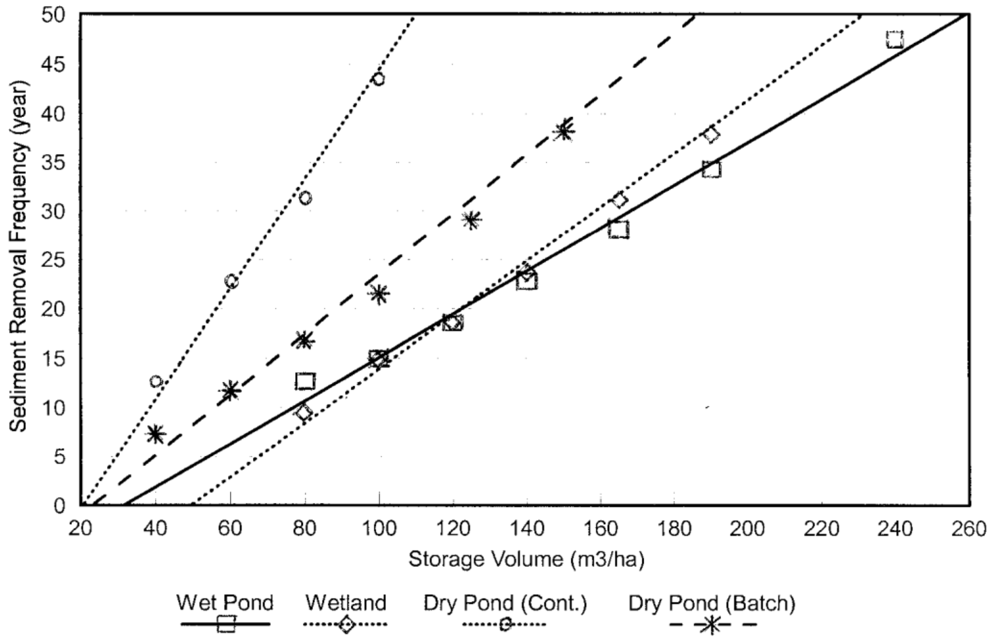

Figure 9-D.2. Storage Volume vs. Sediment Removal Frequency – for 55% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

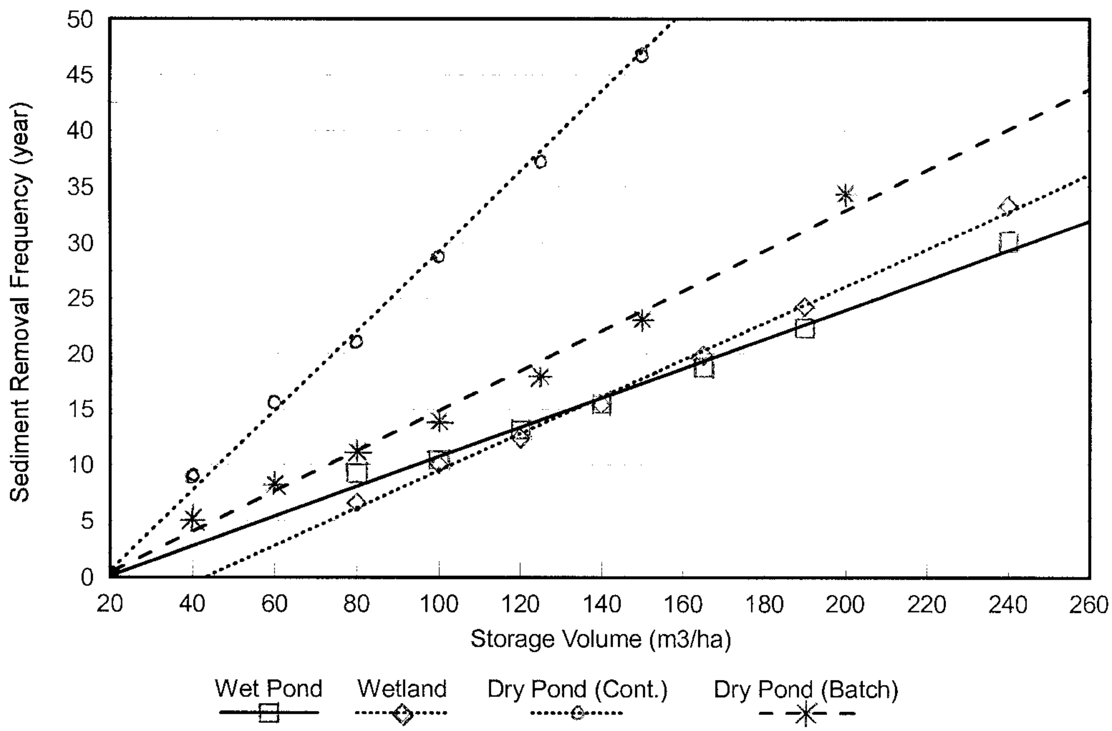

Figure 9-D.3. Storage Volume vs. Sediment Removal Frequency – for 70% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

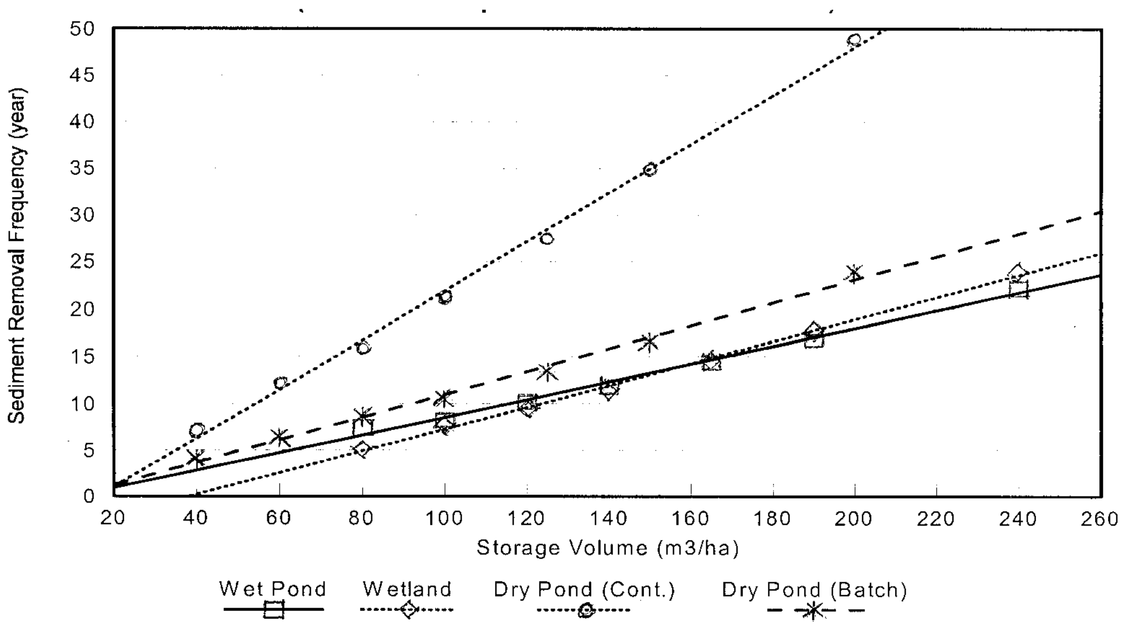

Figure 9-D.4. Storage Volume vs. Sediment Removal Frequency – for 85% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

Figures 9-D.1 to 9-D.4 also indicate that increased storage capacity increases the maintenance interval (i.e., less frequent maintenance is required). These curves are based on the assumption of a 5% loss of performance and should not be used for over-sized facilities. In order to allow users to calculate the required maintenance frequency for an over-sized BMP, annual suspended solids loadings in runoff from catchments with different levels of imperviousness and estimated sediment density are provided in **Table 9-D.1**.

The values of suspended solids loadings in **Table 9-D.1** were derived from U.S. Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) simulation results. They are only intended to be used as estimates for planning purposes. The density of suspended solids was based on a review of the literature of stormwater sediment characteristics and recent pond sediment removal data. The following methodology should be used to calculate the maintenance frequency if storage for the BMP is over-sized (this calculation can be easily automated in a spreadsheet format):

1. Determine the appropriate total suspended solid (TSS) removal efficiency based on the level of protection required for the receiving stream.

2. Subtract 5% to obtain the target maintenance removal efficiency.

3. Determine the projected TSS removal efficiency based on the storage volume provided.

4. Calculate the loss in removal performance and loss in storage for each year, based on the removal performance at the start of the year, the suspended solids loading rate, and the sediment density. The removal efficiency at the start of the next year will be based on the resulting available storage volume at the end of the year. These calculations are continued

until the removal efficiency of the facility at the start of the year is equal to the target maintenance removal efficiency.

Alternatively, a conservative estimate of annual sediment accumulation in a BMP may be obtained by multiplying the annual loading of suspended solids (m^3/yr.) (see **Table 9-D.1**) by the initial removal efficiency for the particular BMP. Using this method, a calculation is made to determine how long it takes to accumulate the difference in storage volumes between the initial storage and the target maintenance storage volume.

Table 9-D.1. Annual Sediment Loadings

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Source: USEPA Stormwater Management Model (SWMM) simulation results

9-E.2.0 REFERENCES

Ontario Ministry of the Environment (OME). March, 2003. *Stormwater Management Planning and Design Manual*.